10/088563

JC10 Rec'd PCT/PTO 15 MAR 2002

A WINSTON 4-23-03

SEAL ASSEMBLY

INS A1

This invention relates to a novel seal assembly.

Natural gas is commonly transported, in bulk, across land through large diameter (eg 24 inch) steel pipelines. It is not uncommon to introduce offtakes or three way joints at certain points on the main transmission pipeline. Currently, a three way joint is welded into the pipeline, following the removal of a section of pipe. This procedure when carried out with gas loaded into the line is hazardous and expensive, involving the installation of a secondary "loop" through which to bypass the gas whilst the joint is installed.

We have now found a novel form of seal which is capable of acting as a primary sealing element that can provide a seal between a main transmission line and bonded branch connection. The seal must withstand service and test pressure including pressure reversals and must also be able to accommodate eccentricity of the branch connection to the main pipeline.

Copending British Patent Application No. 9917 360.1 describes a novel method of securing a branch assembly to a pipeline. Such a method requires a specialised seal which is not only adapted to operate under significant pressures but can also be fitted to non-planar or arcuate surfaces.

British Patent Application No. 1214986 describes a sealing means for use with a pair of pipes which are angularly movable relative to each other. Generally, the sealing means comprises an annular body portion and a pair of spaced tongues, the tongues being provided with inwardly inclined ears. However, the seal described therein is designed for use in connection with "parallel" pipeline flange joints. The seal does not provide a solution to the problem of forming a fluid tight seal in a branched pipeline.

AMENDED SHEET

French Patent Application No. 1549562 describes a seal assembly which comprises a pair of circumferential grooves which are adapted to prevent the ingress of fluid.

Thus it is known to use "U" ring seals in pressure systems wherein the pressure acts on the side wall of the U ring. However, we have now surprisingly found a novel seal assembly which is sufficiently flexible so as to be adaptable to fit parallel, planar, arcuate or convex surfaces.

Thus according to the invention we provide a radial sealing ring assembly adapted for use in a pressurised system which comprises a radial sealing ring provided with at least a pair of primary sealing lips radially disposed on a first, circumferential, face of the ring, a second, axial end face of the radial sealing ring being provided with means for dispersing pressurised fluid characterised in that the means for dispersing the pressurised fluid is a labyrinth seal located on the axial and face.

In a preferred embodiment of the invention the means for dispersing pressurised fluid comprises means for dispensing pressure in a circumferential and a radial direction.

The seal of the invention is advantageous in that it is especially useful in pressure systems since the pressure acts on the walls of the lips and the portion of the seal joining the lips to enhance the pressurised fluid seal produced. The seal will hereinafter be described as a radial sealing ring.

In conventional land based pipe lines the pressure differential is such that the internal face of the seal experiences greater pressure than the external face. Thus, in such an embodiment, the first circumferential face of the seal is the inner face and the second circumferential face is the outer face.

In a further embodiment of the invention the seal arrangement may be such that the external pressure on the seal is greater than the internal pressure. Such seals are, for example, advantageous in that they may be suitable for sub-sea pipelines.

In an alternative embodiment of the invention for use in sub-sea applications, it may be necessary to provide means of sealing to prevent the ingress of water which may be (at times) at a higher pressure than the pipeline fluid. In this case a pair of primary sealing lips may be radially disposed from an outer circumferential face of the radial sealing ring, whilst means for dispersing pressurised fluid is provided on the inner axial end face of the radial sealing ring.

The dispersing means may comprise a labyrinth seal, which may be located on the axial end face of the seal. In a preferred embodiment both axial end faces of the radial sealing ring are provided with a pressurised fluid dispersing member, in which case the labyrinth seals may be the same or different.

Labyrinth seals are known to cause reductions in pressure across the axial end face of the seal. Thus, the labyrinth seals used may comprise an array of apertures. Alternatively, the labyrinth seals may only be partially cut through such that the seal comprises a plurality of hollows or holes. The apertures or holes (together referred to as "the bulkheads") may be arranged irregularly or preferably, in a regular pattern. When a regular pattern is used a 'brick-bond' pattern is preferred, that is, the bulkheads are offset in relation to one another. On opposite sides of the seal faces the bulkheads may be circumferentially offset to one another, for example, by half the pitch of the bulkhead. Alternatively, the bulkheads may not necessarily be offset. Although it is within the scope of the present invention for the labyrinth seals to be separate to the radial sealing ring, or to be bonded to the radial sealing ring, it is preferred that the labyrinth seal is an integral part of the radial sealing ring. When the apertures or holes are in a regular pattern they may comprise two or three circumferential rows. Two circumferential rows are preferred.

The thickness of the labyrinth seal may vary, but is preferably from 1 to 5mm, more preferably from 1.0 to 2.5 mm. The dimensions of the apertures or holes may also be varied depending upon, *inter alia*, the pressure which the radial sealing ring is

AMENDED SHEET

subjected to, the material of which the seal comprises, etc. However, it is preferred that the apertures or holes have a depth of from 0.5 to 2.0 mm and more preferably from 1.0 to 1.5 mm. For ease of manufacturing the apertures or holes are preferably substantially the same size and shape and may be substantially rectangular with dimensions of from 5 to 10 mm radial width by 15 to 20 mm circumferential length, preferably 8 by 16 mm. When rectangular apertures/holes are used then the longest side is preferably circumferential.

Any conventionally known materials may be used in the manufacture of the seals of the invention and preferably the labyrinth seal portion comprises the same material as the U ring portion of the radial sealing ring. Such materials include elastomers and/or plastics. Examples of elastomers include, but are not limited to rubbers, e.g. natural or synthetic rubbers. Of these synthetic rubbers are preferred such as nitrile rubbers, eg acrylonitrile butadiene copolymer (NBR), hydrogenated acrylonitrile butadiene rubber (HNBR), fluoroelastomers (FKM), such as Viton or perfluoroelastomers (FFKM), such as Kalrez. (Viton® and Kalrez® are available from Du Pont Dow Elastomers). Examples of plastics materials include fluorinated polymers such as PTFE (polytetrafluoroethylene).

The hardness of the elastomer, e.g. HNBR, may be varied. However, it is preferred that the hardness lies in the range of from 50 to 95 degrees Shore A.

The pressure which the seals of the invention are designed to tolerate may be up 105 to 110 bar under test conditions and from 20 to 70 bar under conventional operating conditions. Moreover the seals of the invention may withstand external pressures of up to 350 bar, e.g. from 20 to 350, preferably from 70 to 300, more preferably from 105 to 180 bar.

Under operating conditions there may be a risk of circumferential extrusion between the outer portion of the seal and the pipes. Thus, in a preferred embodiment a

AMENDED SHEET

support ring is provided around the outer circumference of the seal eg a coiled spring. The spring is preferentially a metal spring eg a steel spring.

Furthermore, since the radial sealing ring assembly is free to continually expand in a radial direction under the working pressure acting on the lips of the seal. Thus, in a preferred embodiment of the invention the radial sealing ring may be provided with a containment ring. Such a containment ring preferentially comprises a metal ring situated on the non-pressure facing surface of the seal. The containment ring may optionally be integral to the seal ring or may be separate.

Thus in land based pipelines the containment ring is preferentially on the outer surface of the radial sealing ring. However, for use in connection with sub-sea pipelines, the containment ring is preferentially on the inner surface of the radial sealing ring.

In systems where the pressure differential across the radial sealing ring may be variable and/or in sub-sea applications a plurality of radial sealing rings of the invention may be used. For example, an outermost radial sealing ring may comprise a radial sealing ring with outer facing sealing lips and an innermost radial sealing ring may comprise a radial sealing ring with inner facing sealing lips. In such a system the innermost and outermost radial sealing rings may be separate, but may or may not be positioned adjacent to each other.

However, in a yet further embodiment of the invention a radial sealing ring is provided wherein the seal comprises an innermost radial sealing ring and an outermost radial sealing ring which share a common containment ring.

Thus according to a further feature of the invention we provide a radial sealing ring assembly adapted for use in a prescribed system which comprises a pair of primary sealing lips radially disposed on an inner circumferential face of the radial sealing ring, the primary and secondary lips being connected by a containment ring member.

In a preferred embodiment of the invention the radial sealing ring is provided with means for dispersing pressurised fluid as hereinbefore described. Further the radial sealing ring assembly as hereinbefore may comprise a single common containment ring.

The common containment ring may optionally be integral to the radial sealing rings or may be separate.

The radial sealing ring assembly of the invention finds utility particularly as large pipeline seals such as may be required in the oil, chemical, water or gas fields. They are capable of sealing surfaces which are parallel; non-parallel, eg by up to 5mm; or, arcuately eccentric, as may be found when a portion of the sidewall of a pipe may be cut away. The radial sealing rings are especially useful in introducing, for example, a three way joint, into a pipeline by connecting two pipes.

Thus the radial sealing ring assembly may be suitable for use in land based pipelines or sub-sea pipelines.

According to a further feature of the invention we provide a method of introducing a three way joint into a pipeline which comprises a hole in a pipe and attaching a second pipe over the hole wherein the radial sealing ring of the invention lies between the two pipes.

We further provide a method as hereinbefore described which is suitable for use in a variable pressure system, such as a sub-sea system. Such a method may comprise using a plurality of radial sealing rings of the invention. The method especially comprises using an outermost radial sealing ring which may be provided with outer facing sealing lips and an innermost radial sealing ring which may be provided with inner facing sealing lips. In such a system the innermost and outermost radial sealing rings may be separate, but may or may not be positioned adjacent to each other.

The invention will now be described by way of example only and with reference to the accompanying drawings in which;

Figure 1 is a perspective view of a segment of a conventionally used U ring;

Figure 2 is a perspective view of a segment of a radial U ring seal Figure 3 is a cross-section of a segment of a radial sealing ring provided with a labyrinth seal of the invention

Figure 4 is a cross-section of the complete seal of the invention;

Figure 5 is a plan view of the complete seal of the invention;

Figure 6 is a cross-section of the seal of the invention for use in sub-sea pipelines; and

Figure 7 is a cross-section of a branched sub-sea pipeline using the seals of the invention; and

Figure 8 is a cross-section of a dual seal assembly.

Referring to Figure 1 a conventional U ring seal (which is not of the invention) a seal (1) comprises lips (2 and 3) and lip joining section (4) and a body (5). The body (5) has outer walls (6 and 7). The seal (1) which is shown in segment only, is substantially circular such that the wall (6) is on the inside of the circle and the wall (7) on the outside of the circle.

With reference to Figure 2, a radial U ring seal (8) (which is not of the invention) comprises lips (9 and 10), a lip joining section (11) and a seal body (12). The seal body (12) has axial end faces (13 and 14). The seal (8) is substantially circular such the lips (9 and 10) face inwards towards the centre.

With reference to Figures 3 to 5, a radial sealing ring (8) comprises lips (9 and 10), the seal body (12) of the seal being provided with labyrinth seals (15 and 16) on each axial end face (13 and 14) respectively. The labyrinth seals (15 and 16) are in a "brick-bond" arrangement. The seal body (12) of the radial sealing ring (8) is provided with a support ring (17) in the form of a coiled spring moulded into the seal

body (12). The radial sealing ring (8) is also provided with a containment ring (18) on the second or outer circumferential face which is outermost from the centre.

With reference to Figure 6, a sub-sea radial sealing ring (19) comprises primary sealing lips (20 and 21), the body of the seal being provided with labyrinth seals (not shown) as hereinbefore described. The primary sealing lips (20 and 21) are positioned on the outer facing circumferential surface (22) of the radial sealing ring (19). The body is provided with a support ring (23) and optionally with a containment ring (not shown).

With reference to Figure 7, a sub-sea pipeline (24) comprises a main pipe body (25) and a branched pipe (26). The main pipe (25) is provided with an aperture (27) which is coincident with the branched pipe (26). The branched pipe (26) is provided with a flange (28) which overlies the main pipe (25). The gap (29) between the flange (28) and the main pipe body (25) is plugged with radial sealing ring (30) and radial sealing ring (31). Radial sealing ring (30) is provided with inward facing lips (32) which act to prevent leakage from inside the pipeline (24). Radial sealing ring (31) is provided with outward facing lips (33) which act to prevent leakage into the pipeline (24) if the external pressure is greater than the internal pressure.

With reference to Figure 8, a radial sealing ring (37) is adapted for use in a variable pressure system. The radial seal ring (34) comprises a pair of inner facing lips (35 and 36) attached to a first seal body portion (37). The seal body (37) is provided with a support ring (38) and a containment ring (39) and the containment ring (39) is adjacent the support ring (38). The containment ring (39) may be integral to the support ring (38), or may be, for example, fixed onto the support ring (38), or may simply be sandwiched into position.

The containment ring (39) has a first face (40) which abuts or is connected to the support ring (38) and a second opposite face (41). The second face (41) is situated

AMENDED SHEET

adjacent to a second support ring (42), the support ring (42) being attached to a second seal body (43) which is provided with lips (44 and 45).

Each of the bodies (37 and 43) is provided with labyrinth seals (46, 47, 48, 49) on the respective axial end faces (50, 51, 52, 53).

P36131WO.6

AMENDED SHEET